Ore Deposits & Tectonics

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ORE DEPOSITS and the Tectonic Cycle

- Geologists had a static concept of the earth until 19th century i.e. they believed that it was created exactly as we see it today.
- In the early years of 19th century, the new way of looking at the earth included the recognition that constant changes take place as geological forces modify the surface and interior of the earth.
- The geological cycle as deduced by Hutton postulates that the geological environment in any place undergoes a cyclic change through a number of stages as outlined below:

➢ Erosion and planing down of mountains - The Weathering Stage.

➢ Formation of sedimentary rocks - The Sedimentary Stage.

➢ Burial in the deep crust - The Plutonic Stage.

➢ Folding, faulting, mountain building and igneous intrusion - The Orogenic Stage.

ORE DEPOSITS and the Tectonic Cycle

- It must be considered that since ores are rocks, they are likely to be intimate parts of the environment in which they occur.
- This is supported by the evidence obtained from the examination of a wide variety of ores and the geological environment in which they occur.
- It is confirmed that most ore deposits indeed appear to be related fundamentally to their environment.
- To be more specific, ores are not merely parts of their environment, each one of them is a characteristic part of a particular type of environment.
- This realization leads to another important principle --the geological environment existing in any segment of the earth's crust or surface is not static -- it is constantly changing.
- In most cases the changes involved are progressive and systematic, that is to say that the environmental metamorphosis follows an evolutionary pattern. This systematic change is referred to as CRUSTAL EVOLUTION.
- Most of these changing environments are those that have certain ore deposits of their own particular characteristic kind.

Plate Tectonics & Ore Deposits

- Plate tectonics, like crustal evolution, provides a basis for understanding the distribution and origin of mineral and energy deposits.
- The Relationship can be understood by following reasons:
    - Geological processes operating due to energy released at plate boundaries control the process of mineral deposition.
    - Mineral deposits form in particular tectonic settings which are governed by plate tectonics.
    - Reconstruction of fragmented continents can provide a useful basis for exploration of new mineral deposits.

Four Scenarios:

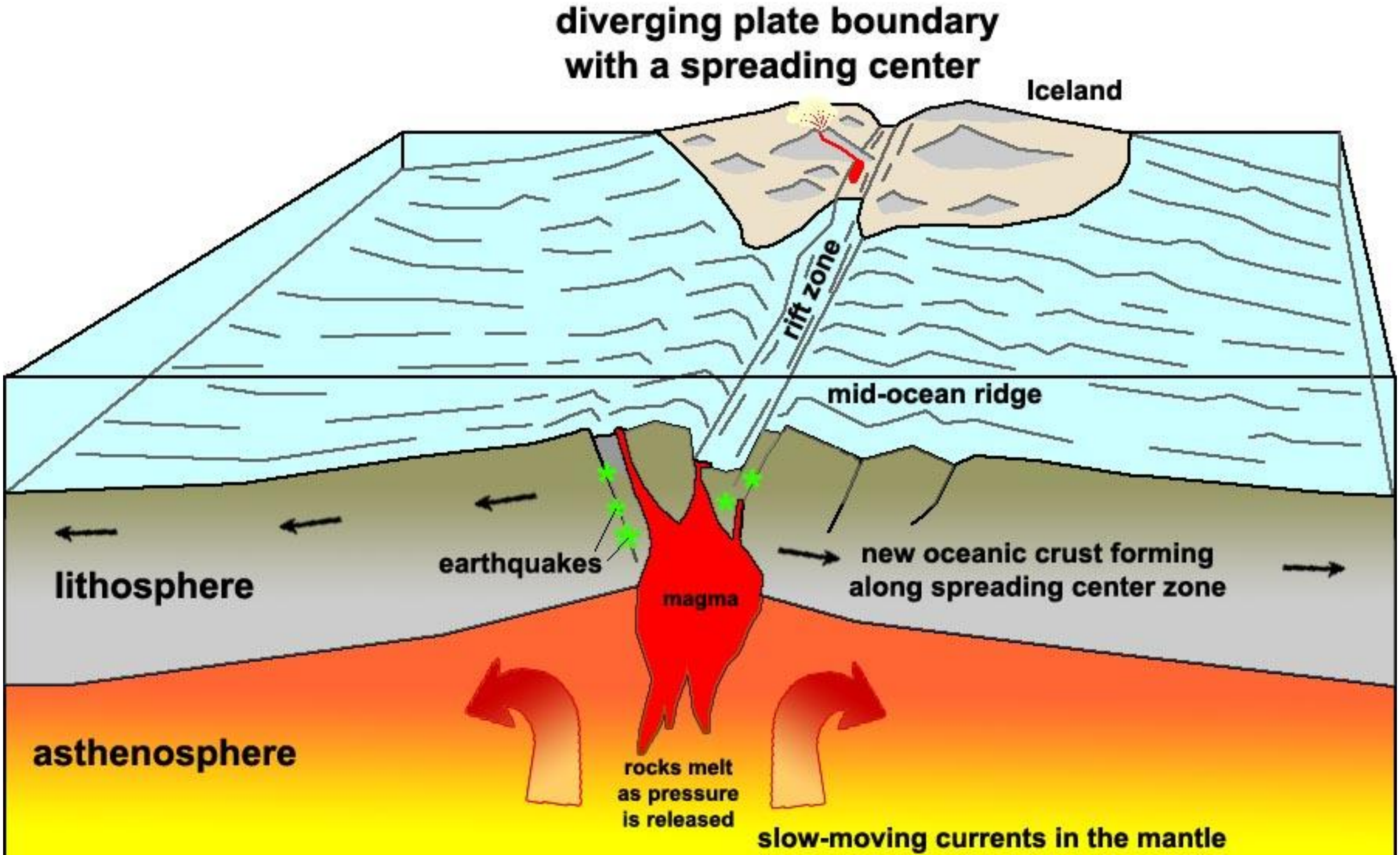
I. Deposits at oceanic ridges (divergent plate margins)

II. Deposits at convergent plate margins

III. Deposits in cratonic rift systems

IV. Deposits in cratonic basins

Deposits at oceanic ridges



Deposits at oceanic ridges

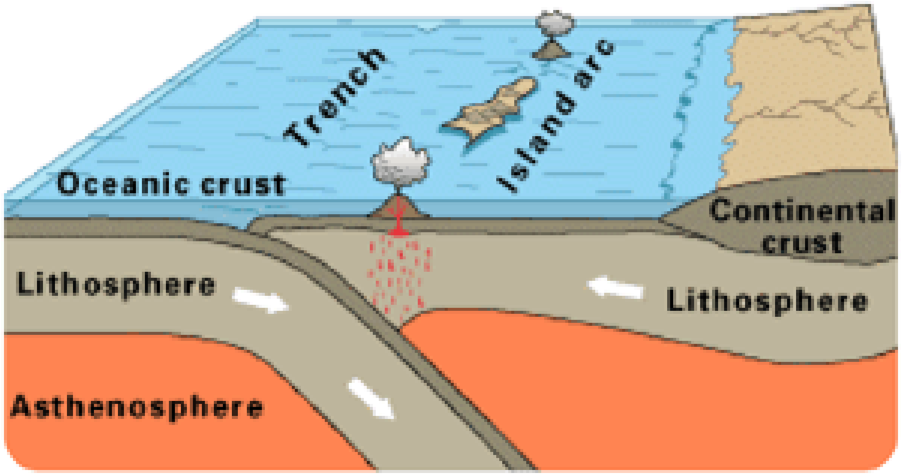
Hydrothermal activity at the ridges gives rise to

a) Sulfide deposits
b) Metalliferous sediments on the flanks of ridges.

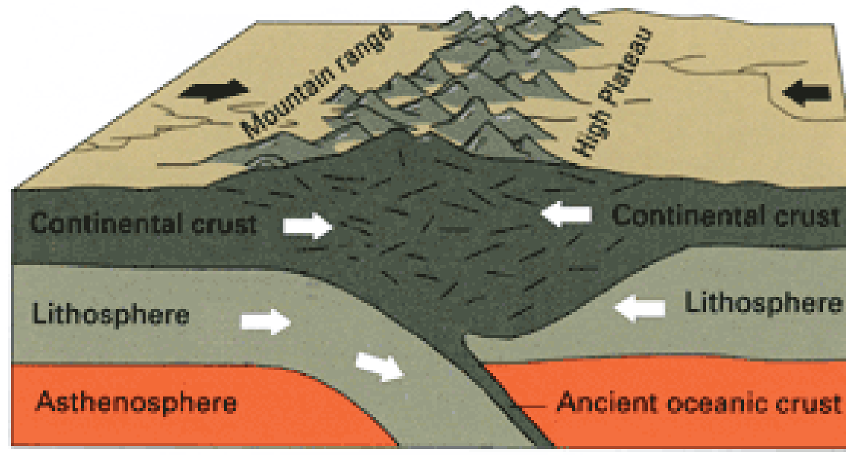
Important metallic deposits formed are Fe, Zn, Cu, Pb, Au and Ag.

- In the Red Sea metalliferous sediments containing Fe, Zn and Cu are being deposited.
- Podiform chromite deposits associated with serpentinized ultramafic rocks.
- Cyprus Type massive sulfide deposits (Cu-Fe rich) are also associated with ophiolites and represent hydrothermal deposits formed at ocean ridges.

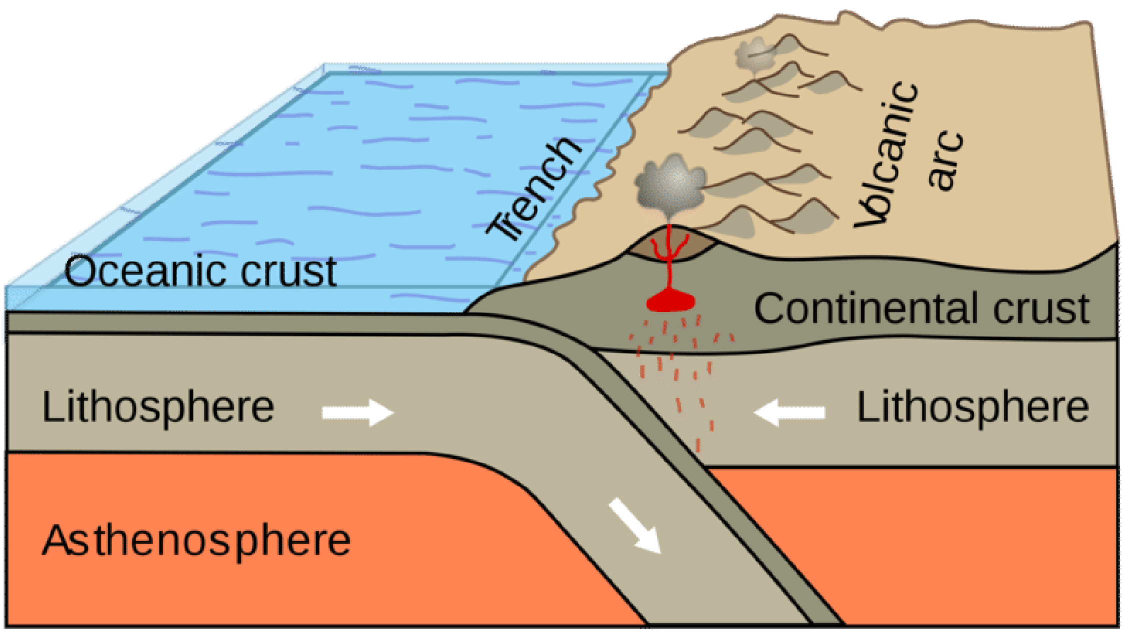
Deposits at convergent plate margins



Oceanic-oceanic convergence



Continental-continental convergence



Deposits at convergent plate margins

Along the Circum-Pacific Belt major metallic deposits occur in western North and South America, Japan, Philippines, New Zealand and Indonesia.

More than half of the world's supply of copper comes from the Porphyry Copper Deposits of this region.

Important deposits associated with present and former convergent margins are:

- Base metals (Cu, Pb, Zn, Mo).
- Precious metals (Pt, Au, Ag).
- Other metals (Sn, W, Sb, Hg).
- (Red Bed uranium deposits are also associated with convergent boundaries).

Deposits at convergent plate margins

Zoning of mineral deposits forming at convergent margins is apparent

For example in the Andes, going from west to east, the various zones encountered are:

a) contact metasomatic Fe- deposits;

b) Cu-Ag and Ag veins;

c) Porphypy Cu-Mo deposits;

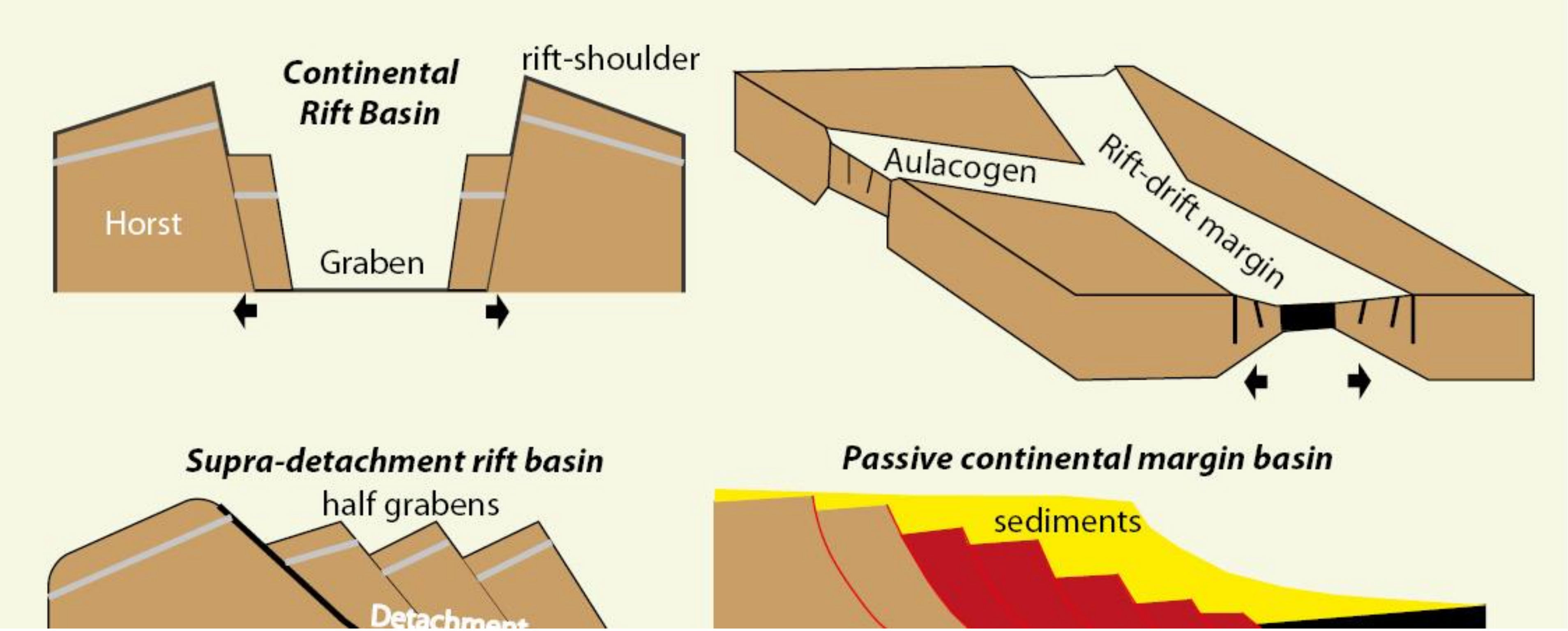
d) Pb-Zn-Ag veins and contact metasomatic deposits; and

e) Sn deposits.

These zones are caused due to progressive liberation of metals from the descending slab, with Sn coming from a depth of 300 Km.

Petroleum occurs in the back-arc basins in arc convergent margins where organic matter is trapped and there is a lack of free circulation so that its oxidation is prevented.

Deposits in cratonic rift systems



Deposits in cratonic rift systems

Regional uplift and doming usually result when a continent comes to rest over a hotspot and huge volumes of magma rise to the surface.

Extensional failure of the lithopheric crust may occur with continued doming, triggering the development of a triple junction - a three armed continental rift system.

Typically, one arm of the rift fails remaining a fissure in the crust known as an aulacogen, while the remaining two arms open to form an oceanic basin.

The prevalence of three armed rifts is revealed by reassembling the continents surrounding the Atlantic Ocean to their positions before Pangea split up. In most cases two of the arms were incorporated into the Atlantic, while the third remained as a blind rift extending into the continent.

Deposits in cratonic rift systems

Rifting follows crustal doming in response to hot-spot activity in the mantle.

Granites intruded at this stage have associated Sn and fluorite deposits.

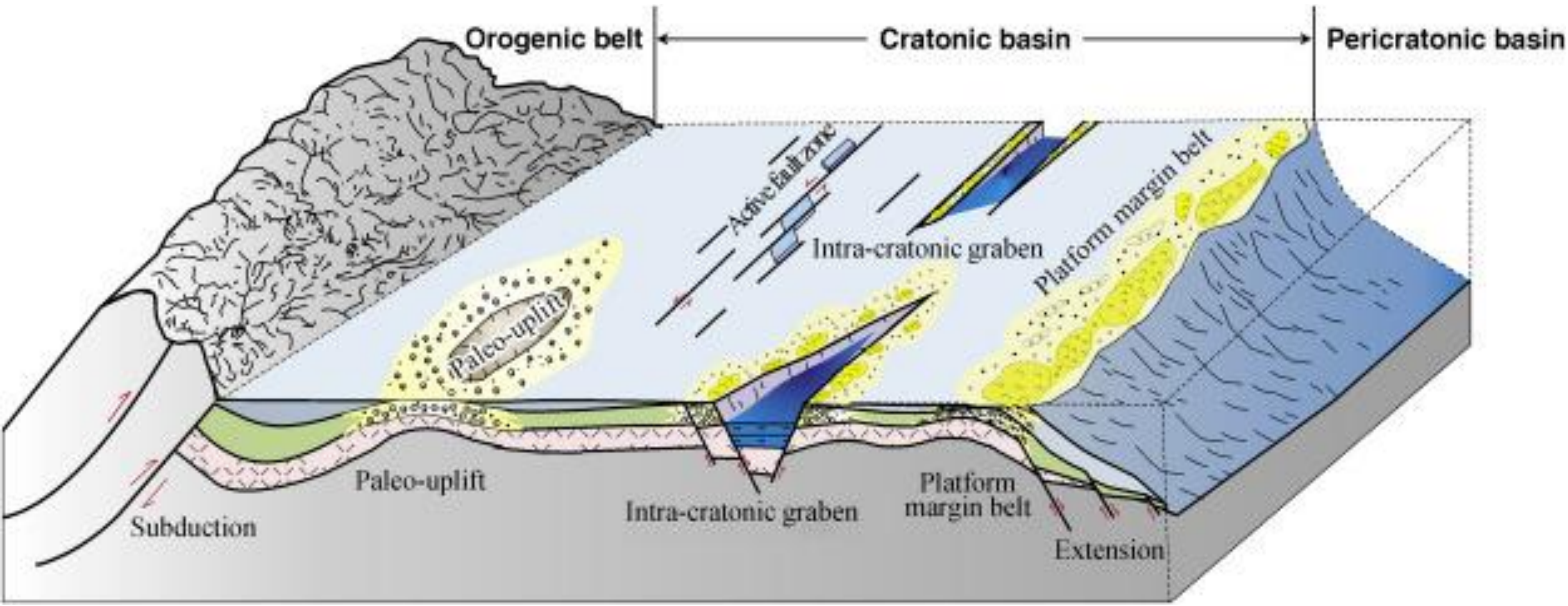
Evaporites accumulate in the rifts during the more advanced stages, with Pb-Zn-Ag deposits in limestones forming during the early and middle stages of rifting.

These are followed by oceanic metalliferous deposits.

Aulacogens are characterized by the presence of fluorite, barite, carbonatites (with Nb, P, REE, U, Th etc) and Sn-bearing granites.

Carbonatites (considered to be mantle derived), kimberlites and alkaline granites within or adjacent to rifts provide a major source of metallic and other minerals.

Deposits in cratonic basins



Deposits in cratonic basins

- Marginal and intracontinental cratonic basins provide a favourable setting for accumulation of organic matter.

- During the opening of a cratonic rift, seawater moves into the basin and evaporation exceeds inflow, giving rise to the formation of evaporites.

- The environment is characterized by restricted circulation and hence organic matter is preserved leading to the accumulation of petroleum.

- With continued rifting, circulation becomes unrestricted and deposition of evaporites and organic matter ceases.

- Oil and gas may also be trapped in structural and stratigraphic traps as they move up due to increasing temperature and pressure, Eg the Red Sea.